

130P-1

## BUILDING STRUCTURES, FRAMING & RAFTERS

AG 130-P

### UNIT OBJECTIVE

After completion of this unit, students will be able to identify the importance and scope of the agricultural mechanics industry in the United States, Idaho, and the local community. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

### SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. List factors to consider when planning a farm building.
2. Label types of doors used on farm utility buildings.
3. List common types of foundations and wall supports.
4. List factors to consider when selecting roofing materials.
5. List factors to consider when selecting siding material.
6. List ways to protect siding from decay or damage.
7. Distinguish among paints and the types of surfaces on which they are used.
8. List characteristics to look for when selecting paint.
9. Determine the cost of a farm building.

## BUILDING STRUCTURES

### A. Terms Used in Building Structures, Framing & Rafter Construction

1. Sill – Horizontal timbers which form the lowest members of a frame supporting the superstructure of a building.
2. Stud – An upright member, usually a piece of dimension lumber, used in the framework of a wall.
3. Plate – Term usually applied to a 2 X 4 placed on top of studs in frame walls.
4. Purlin – A beam spanning the principle roof supports
5. Ridge – The highest point of a roof composed of sloping sides.
6. Truss – A combination of members such as beams, bars, and ties usually arranged in triangular units such to form a rigid framework for supporting loads over a ling span.
7. Rafters – Sloping members of a roof such as the ribs which extend from the ridge or from the hip of a roof to the eaves.
8. Girder – A large supporting built-up horizontal member used to support walls or joists.
9. Gusset – A brace or angle bracket used to stiffen a corner or angular piece of work.
10. Knee Brace – A framing member placed across the inside of an angle in a frame work to add stiffness to the frame.
11. Utility building – Building designed to be used for a variety of purposes. ( equipment storage, animal shelter, shop, service center, etc)
12. Span – Distance from outside of top wall plate on one exterior wall to outside of top wall plate on opposite wall.
13. Run – Horizontal distance from center of ridge board to outside of wall plate.
14. Pitch – Slant or slope of a roof, the proportion of the rise to the span
15. Rise – Vertical distance from top of wall plate to top of ridge board.
16. Ridge Board – Horizontal member at top of the roof to which the upper end of the rafters are attached.
17. Seat Cut – the cut at the end of the rafter that rests on the plate
18. Slope – the slant of a rafter, it is the rise per foot of the run
19. Upper Plumb Cut – the vertical cut at the top end of the rafter
20. Lower Plumb Cut – the vertical cut at the lower end of the rater

### B. Factors to Consider, When Planning a Farm Building

1. Decide the size of building needed.
2. Decide the location of the building.
3. Decide the type of building needed.
4. Decide the kind of materials to use.

5. Consult persons experienced in building and in the use of agricultural buildings.
6. Figure bill of materials and the total cost of the building (look under AG 130-I)
7. Decide to build it yourself or hire a contractor to build it. (consider; time, labor costs, size of the project, the tools it will take to construct a building, etc and if using a contractor, several bids should be considered)
8. Alternate Uses
9. Future Expansion

C. Factors to Consider, When Selecting Roofing Materials

1. Probable life expectance due to weathering
2. Fire resistance
3. Annual snow fall
4. Resistance to heat and sun
5. Resistance too strong wind
6. Maintenance
7. Minimum slope for application
8. Weight
9. Kinds of fasteners required
10. Labor and Cost
11. Skill required for construction
12. Type of roofing material
  - a. Galvanized steel
  - b. Aluminum sheets
  - c. Wood shingles
  - d. Asphalt shingles
  - e. Asphalt roll
  - f. Fiberglass sheets
  - h. Steel sheets with backed on enamel

D. Factor to Consider, When selecting siding material

1. Life expectancy due to weathering
2. Fire resistance
3. Resistance to attack by vermin
4. Maintenance
5. Ability to be painted
6. Type of fastener needed
7. Cost
8. Ease of construction
9. Protecting Siding from Decay or Damage

- a. Use treated lumber
- b. Keep siding at least 6" above ground level
- c. Provide drainage away from all sides of the building
- d. Provide eave troughs and down spouting to keep water from spilling on sides.
- e. Provide 8" to 20" of overhang on all sides of the building
- f. Paint and characteristics to look for when selecting paint

- 1) Durability
- 2) Self-cleaning (wears off gradually and keeps the surface relatively clean)
- 3) Highly reflective
- 4) Dirt resistant
- 5) Non-sensitive to moisture (resistant to blistering and peeling)
- 6) Good hiding or covering qualities

#### E. Types of Doors

##### 1. Sliding

- a. Attaches to a track.
- b. Can be made to fit.
- c. Can be made of almost any type of material.

##### 2. Overhead

- a. Commonly used on garages.
- b. Mounted on track or guide.
- c. Raised out of the way when open.
- d. Attractive
- e. More convenient to operate
- f. Higher cost
- Limited in number of sizes

##### 3. Walk-Through

- a. Most common for all buildings
- b. Small size
- c. Used primarily for human traffic
- d. Easy to install
- e. Ease in entering a building

E. Common types of foundations and wall supports

1. Wood or steel poles or posts and piers
2. Light wood frame with masonry or concrete foundation
3. Post and girt with masonry or concrete foundation
4. Masonry walls on concrete foundations
5. Steel structures
6. Combinations of above

F. Types of Floors, Advantages and Disadvantages

1. Dirt

a. Advantages

- 1) Least expensive
- 2) Absorbs oil and water

b. Disadvantages

- 1) Tools and equipment sink into the dirt.
- 2) If floor is damp it provides enough moisture to rust tools and equipment.
- 3) If the floor is dry, dust will usually be a problem with each gust of wind.
- 4) Very difficult to clean

2. Crushed Rock

a. Advantages

- 1) Dust is much less of a problem
- 2) Absorbs oil and water

b. Disadvantages

- 1) Not satisfactory in livestock structure of cleaning problems
- 2) It holds dirt and grease
- 3) Tools and equipment will

3. Concrete

a. Advantages

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- 1) If properly placed, forms a hard dry surface
- 2) Easy to keep clean
- 3) Forms an excellent base for equipment and power tools
- 4) Excellent for livestock structures
- 5) It is fireproof and usually costs less than a wooden floor

### b. Disadvantages

- 1) Colder than wooden flooring
- 2) More tiring to stand on when working continuously
- 3) More expensive than most types of flooring

## 4. Wood

### a. Advantages

- 1) Warmer during cold weather
- 2) Less tiring to stand on for long periods of time

### b. Disadvantages

- 1) More expensive than most floors
- 2) May not be strong enough to support heavy equipment
- 3) Fire hazard especially in a shop
- 4) Short life compared to concrete

## E. Type of Farm Utility Buildings

1. Shed - Roof
2. Gable – Roof
3. Half – Arch
4. Full – Arch
5. Pole Barn

## F. Factors to consider when selecting siding

1. Life expectancy due to weathering
2. Fire resistance
3. Maintenance
4. Ability to be painted
5. Type of fasteners needed
6. Ease of construction

G. Factors to consider when selecting paint

1. Durability
2. Highly reflective
3. Dirt resistant
4. Resistant to rain and discoloration
5. Use

I. Causes of building failures

1. Builder did not use the grade and type of material called for in the specifications
2. Builder did not make joints as strong as the structural member
3. Inadequate foundation

FRAMING

A. Components in Framing

1. Sills – a 2" X 4" (or 2" X 6" depending on the studs used) attached to the foundation
2. Studs – The upright wall members, usually spaced 16" (note the marks on a tape measure at 16, 32, 48, 64 etc. are used in spacing studs) or 24" to provide modular spacing that conforms with common building materials. The width of the stud depends on the building loads, ceiling height and building codes for type of buildings.
3. Plates – the horizontal member on top of the studs, it adds strength to the wall and must be wide enough to support the rafters
4. Headers – are required to span openings such as windows and doors, often used with the regular plates that are already in place.

B. Connections in Framing

1. Toe-nailing (See Page 130P-17)
  - a) Toe-nailing is nailed through the face of the boards and not the edges, if nailed through the edges the chances of splitting increase.
  - b) Position the point of the nail so that one-third of the nail is in the stud and two-thirds in the sill or plate.
2. End-nailing (See Page 130P-17)
  - a) Nailing through the sill or plate into the stud

### 3. Clinching

- a) When the nails go through the two pieces of wood being nailed together the excess needs to be bent over into the wood.

### 4. Nailing into the grain

- a) Nail across the grain of the wood to prevent the wood from splitting.
- b) Nailing with the grain will result in splitting and weaken the board.

## C. Bracing in Framing

### 1. Lateral bracing

- a) Lateral bracing in a frame is obtained by a brace (usually a 1" X 4") notched into the studs, at each corner in both directions.
- b) Using plywood to cover the frame gives the best support for bracing.

### 2. Knee bracing

- a) Knee bracing is used between columns and beams for lateral resistance to wind.
- b) Knee braces should be made of 2" X 4" and a minimum of 4' in length (mostly used in pole barn or out building construction).

## D. Framing Doors and Windows

1. Header – a 4" X 8" piece of lumber used for framing the tops of doors and windows to support the upper walls or roof
2. Double header – two 2" X 8" pieces of lumber fastened together used as a header
3. Filler studs – studs used for supporting headers, always attached to a full stud
4. Cripple studs – studs placed at the normal spacing (16 or 24 inches) above and below windows and above doors
5. Sill header – a horizontal piece of lumber used at the bottom of a window frame; sometimes, double sills are used for larger windows



## RAFTER FRAMING

### A. Terms Used in Rafter Framing

1. Rise – the vertical distance from the top of the plate to the center of the work line
2. Run – the horizontal distance from the outer edge of the plate to the center of the ridge, on equal pitch roofs the run is equal to one-half the span
3. Span – the distance between structural supports
4. Ridge – the horizontal line at the junction of the top edges of two sloping roof surfaces, the rafters of both slopes are nailed to a board at the ridge
5. Slope – the incline of a roof, expressed as inches of rise per foot of run
6. Pitch – the ratio of the total rise to the total width of a building; example, 8' rise and a 24' width make a 1/3 pitch
7. Tail – the part of the rafter that overhangs the eave of the building
8. Common Rafter – a structural member of a roof in a straight line from the plate to the ridge
9. Valley Rafter – a rafter which runs from a wall plate to the ridge, along the valley of a roof
10. Jack Rafter – a rafter placed between the top plate and a hip rafter or a valley rafter to a ridge board
11. Hip rafter – a rafter that extends from the wall plate to the ridge of the roof and forms the angle of a hip roof

### B. Use of A Framing Square

1. Parts of a framing square
  - a. Body – the longer and wider member, 24" in length and 2" wide
  - b. Tongue – the shorter and narrower member, 16" in length and 1 1/2" wide
  - c. Heel – the outside edge where the body and tongue meet
  - d. Face – Holding the tongue in the right hand with the body pointing toward the left hand and the heel pointing away from you, you will be looking at the face. The manufacture's name is usually on the face side of a framing square.
  - e. Back – Holding the tongue in the left hand with the body pointing toward the right hand and the heel pointing away from you, you will be looking at the back.

2. Tables on the Framing Square

(Note; books on how to read these tables and scales can be found at your local hardware store)

- a. Rafter table – this table is found on the face-side of the body and can be used as a short cut to figuring out rafter length
- b. Octagon scale – this scale is found on the face-side of the tongue and can be used in construction of eight sided structures
- c. Brace measure – this table is found on the backside of the tongue and gives the length of common braces
- d. Essex board measure – the table is found on the backside of the body and can be used for measuring board feet

C. Cutting a Common Rafter (See Page 130P-15)

1. Determine the slope

- a.  $\text{Slope} = \text{inches of rise for each foot of run}$

2. Determine the length

3. Mark off the length of the rafter as calculated from the rafter table

4. Mark out the plumb cut

5. Mark out the seat cut

6. Make an allowance for the thickness of the ridge piece

7. Add the amount of stock needed for the rafter tail

8. Cut the rafter and check the fit of the seat and plumb cuts

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Phipps, Lloyd J., and Miller, Glen M.(1998) AGRISCIENCE MECHANICS. Danville, IL: Interstate Publishing

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Lindley, J. A., & Whitaker, J. H. (1996) AGRICULTURAL BUILDINGS AND STRUCTURES, REVISED EDITION. American Society of Agricultural Engineers, St. Joseph, MI, <http://asae.org/>

Name \_\_\_\_\_

Date \_\_\_\_\_

Score \_\_\_\_\_

## Worksheet, Rafter Cutting

Using a 1" X 4" 4' piece of lumber you will cut out a rafter to the following specification.  
Answer questions 1 and 2 before marking out the rafter, double check with your instructor before making any cuts.

1. What is the slope of your rafter? You have 12" of rise to 36" of run.

Slope = \_\_\_\_\_

2. What is the length of your rafter?  $A^2 + B^2 = C^2$  or use the rafter table on a framing square. (Show your work)

Rafter Length = \_\_\_\_\_

3. Mark off the length of the rafter as calculated.

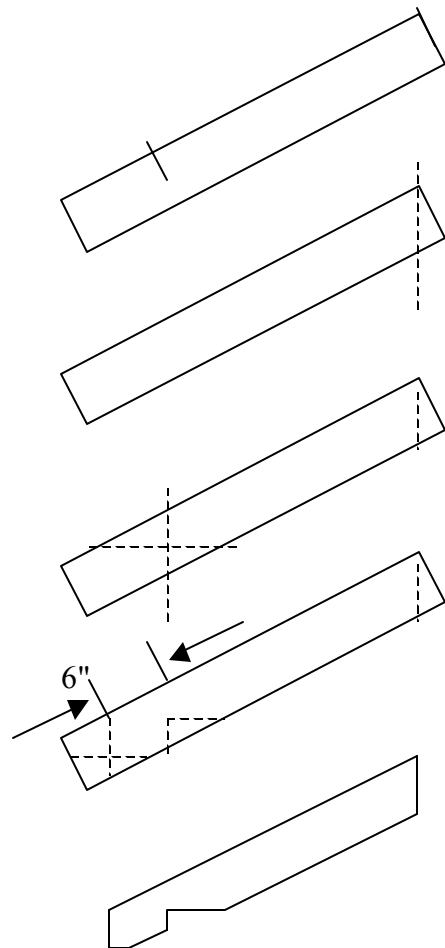
4. Mark out the plumb cut using a framing square.

5. Mark out the seat cut to fit a 1  $\frac{3}{4}$ " X 3  $\frac{3}{4}$ " plate.

6. Mark and add 6" to the rafter length for the rafter tail

7. Cut rafter and check the fit of the seat and plumb cuts

8. After you have completed your rafter cuts, turn in your rafter with this worksheet for grading



Name \_\_\_\_\_  
 Date \_\_\_\_\_  
 Score \_\_\_\_\_

### Unit Exam, Structures, Framing & Rafter Cutting

Match terms on the left with the correct definitions on the right.

- |   |                     |
|---|---------------------|
| 1. _____ Building designed to be used for a variety of purposes.  | A. Sill             |
| 2. _____ Sloping members of a roof which extend from the ridge of a roof to the eaves.                                | B. Rise             |
| 3. _____ The cut at the end of the rafter that rests on the plate   | C. Slope            |
| 4. _____ Horizontal distance from center of ridge board to outside of wall plate.                                     | D. Span             |
| 5. _____ An upright member, usually a piece of dimension lumber, used in the framework of a wall.                     | E. Ridge            |
| 6. _____ Term usually applied to a 2 X 4 placed on top of studs in frame walls.                                       | F. Run              |
| 7. _____ Horizontal timbers which form the lowest members of a frame supporting the superstructure of a building.     | G. Utility Building |
| 8. _____ The slant of a rafter, it is the rise per foot of the run  | H. Seat Cut         |
| 9. _____ Vertical distance from top of wall plate to top of ridge board.  | I. Rafters          |
| 10. _____ Distance from outside of top wall plate on one exterior wall to outside of top wall plate on opposite wall. | J. Plate            |
| 11. _____ The highest point of a roof composed of sloping sides.  | K. Stud             |
| 12. _____ the vertical cut at the top end of the rafter   | L. Upper Plumb Cut  |

Answer Sheet:

Unit Exam

1. G
2. I
3. H
4. F
5. K
6. J
7. A
8. C
9. B
10. D
11. E
12. L

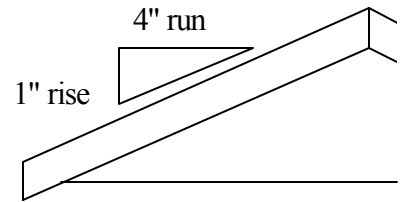
Worksheet, Rafter Cutting

1. Slope =  $\frac{1}{3}$
2. Rafter Length = 37.95

## CUTTING THE COMMON RAFTER

### 1. Determine the slope (Slope = inches of rise for each foot of run)

Examples:  $1/4$  slope = 3" of rise to 12" of run =  $3/12 = 1/4$  or  
 $1/3$  slope = 4" of rise to 12" of run  
 $1/2$  slope = 6" of rise to 12" of run

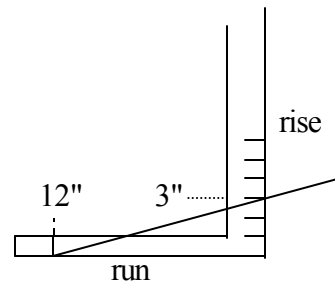


### 2. Determine the length (The length of the rafter is the hypotenuse of a right triangle) $(A^2 + B^2 = C^2, C^2 = \text{the length of the rafter})$

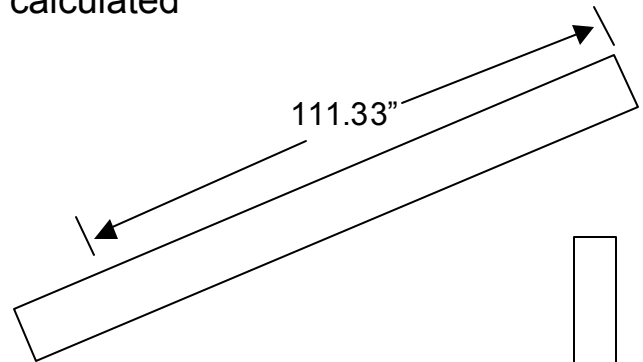
Example: A  $1/4$  slope with 9 feet of run =  $108^2 + 27^2 = 111.32^2$  Rafter length = 111.32"  
 $(9 \rightarrow 12 = 108 \text{ and } 9 \rightarrow 3 = 27)$

OR

Using the Rafter table on a framing square,  
 On the common rafter table, at the 3" mark you will see 12.37  
 Remember 9 feet of run  $9 \rightarrow 12.37" = 111.33"$   
 Rafter length = 111.33"  
 Within one one-hundredth of each other is close enough

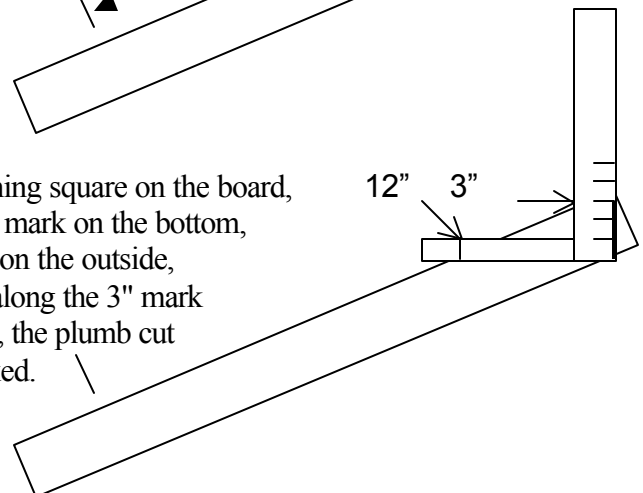


### 3. Mark off the length of the rafter as calculated

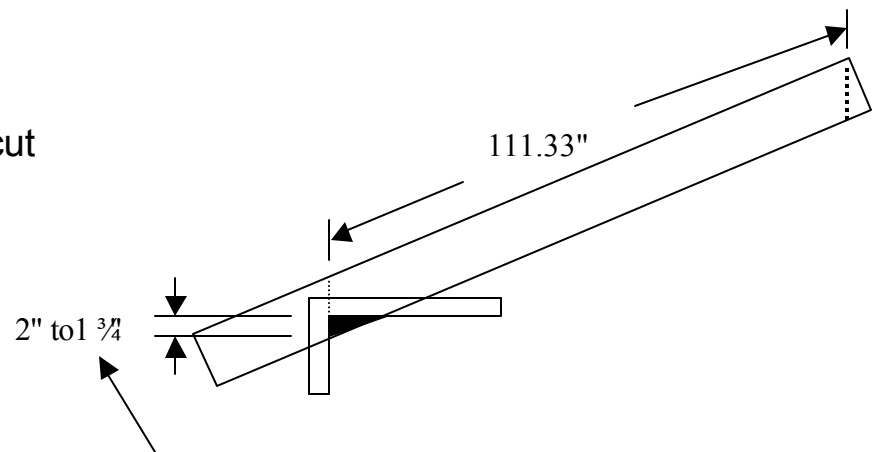


### 4. Mark out the plumb cut

Lay the framing square on the board, with the 12" mark on the bottom, the 3" mark on the outside, draw a line along the 3" mark as illustrated, the plumb cut is now marked.

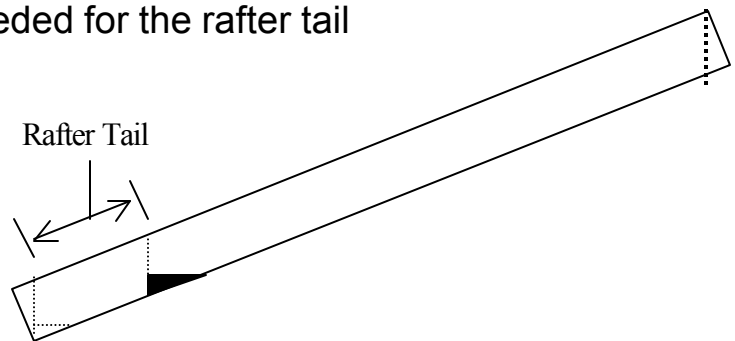


5. Mark out the seat cut

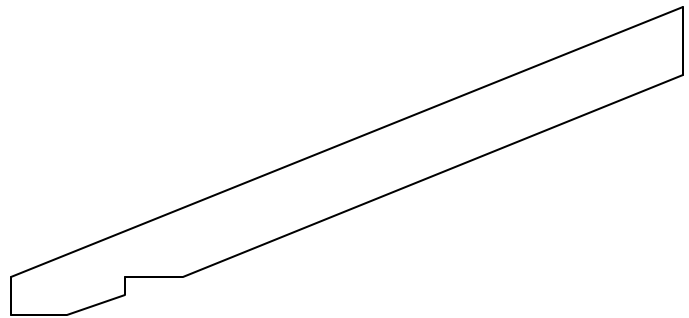


6. Make an allowance for the thickness of the ridge piece

7. Add the amount of stock needed for the rafter tail



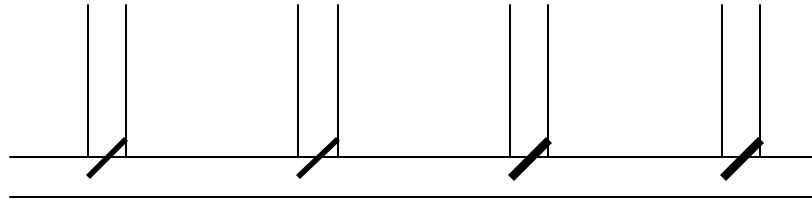
8. Cut the rafter and check the fit of the seat and plumb cuts



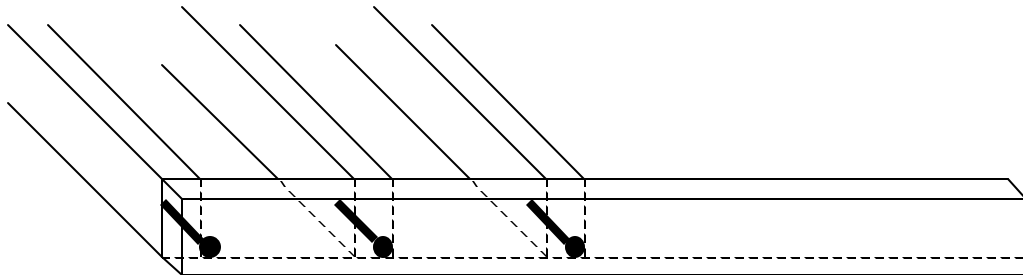


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## NAILING



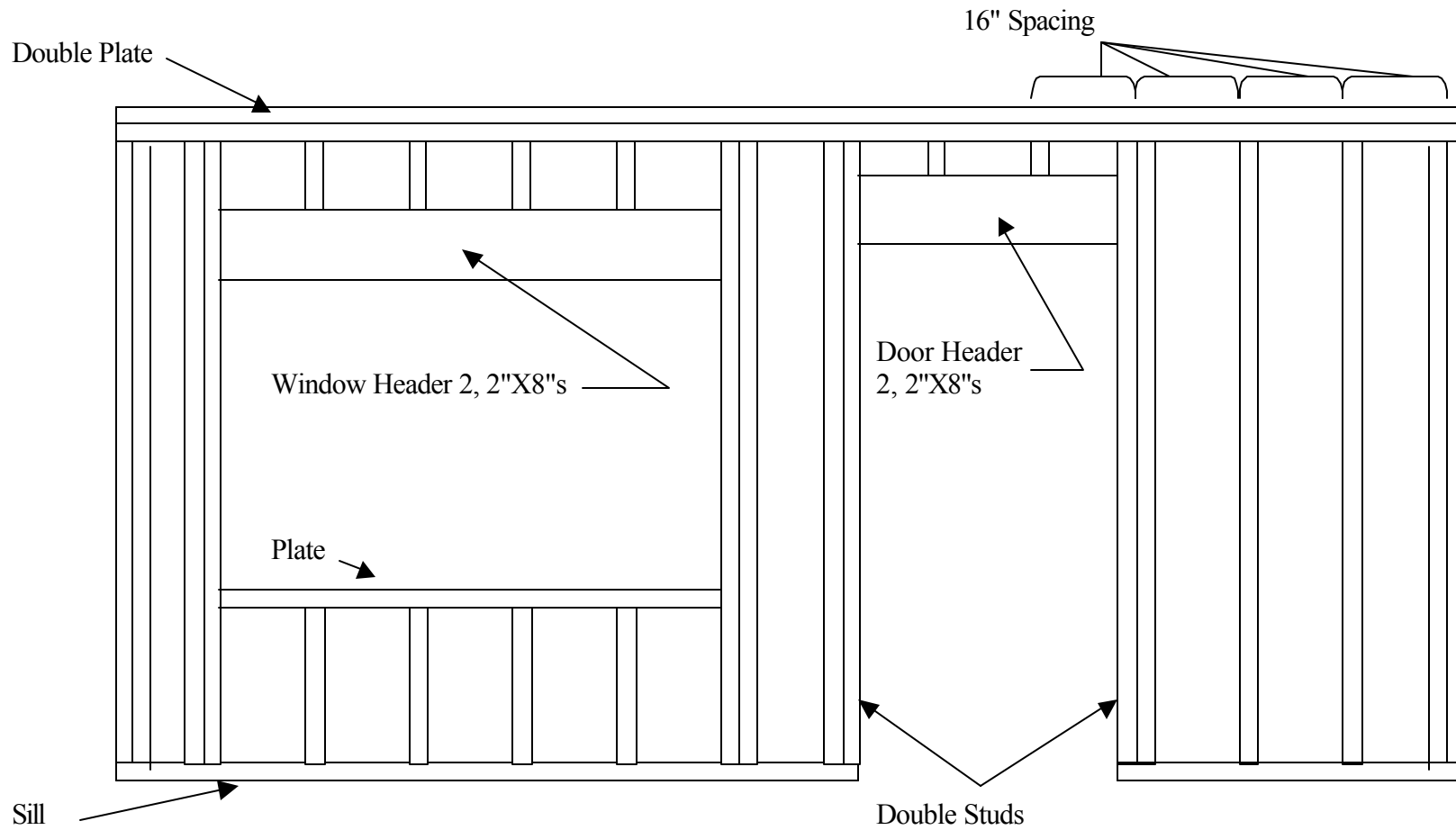
TOE-NAILING



END-NAILING

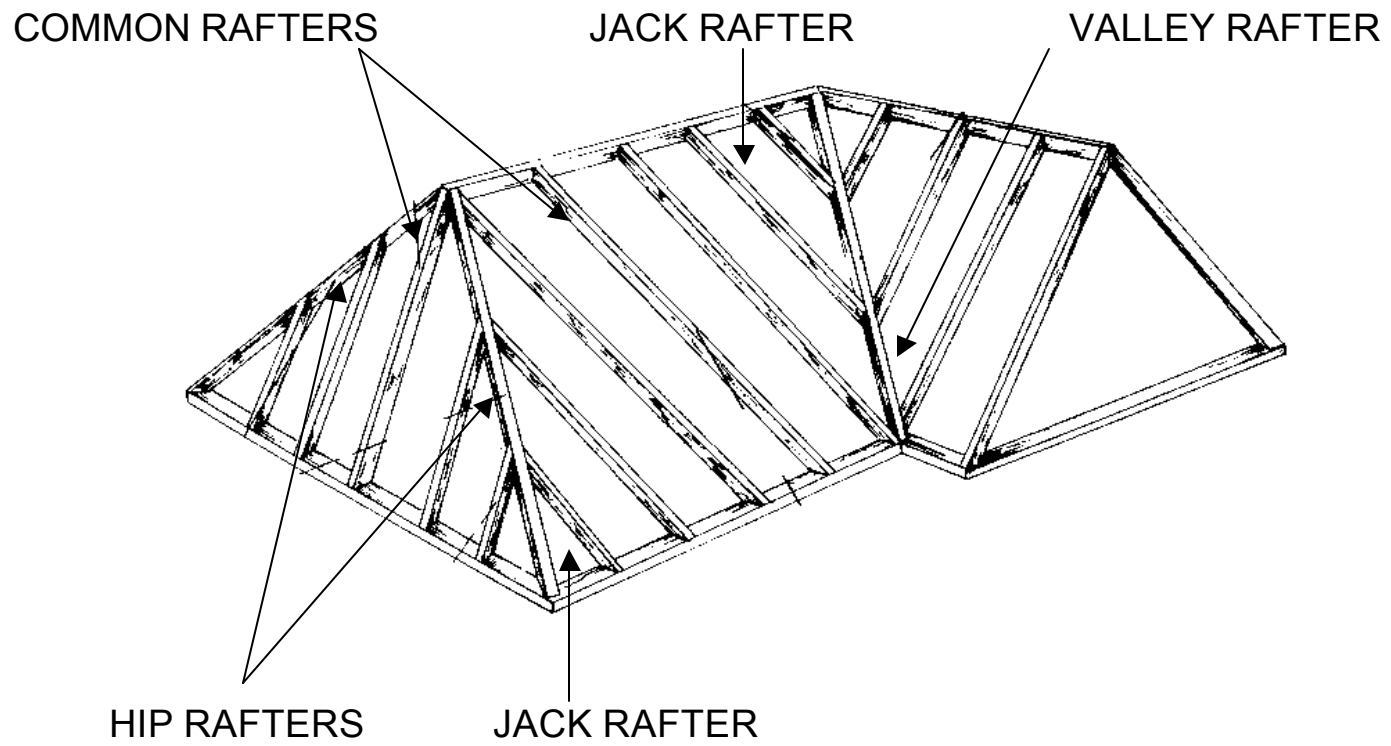
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## FRAMING WALLS, WINDOWS & DOORS



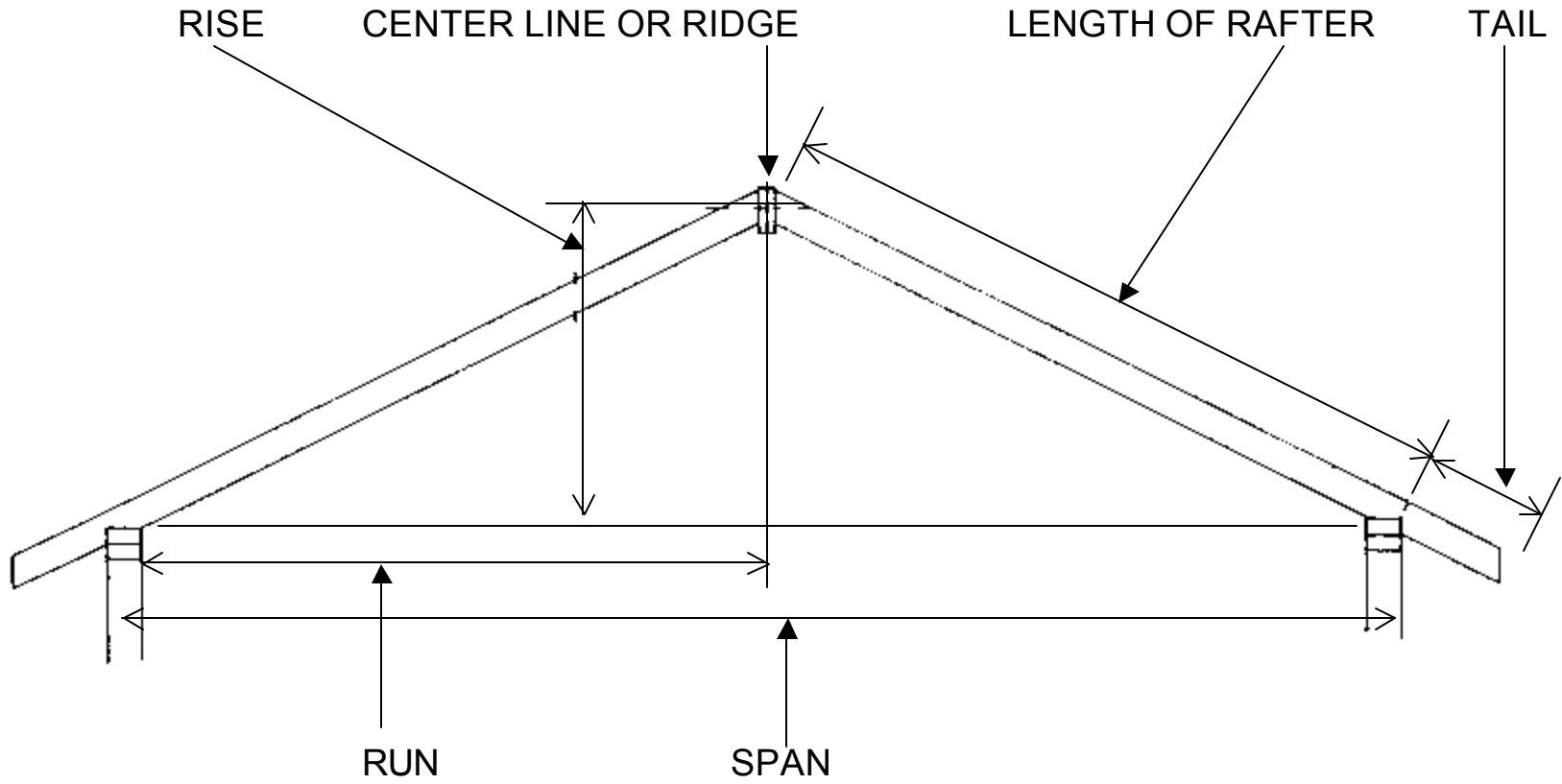
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## TYPES OF RAFTERS



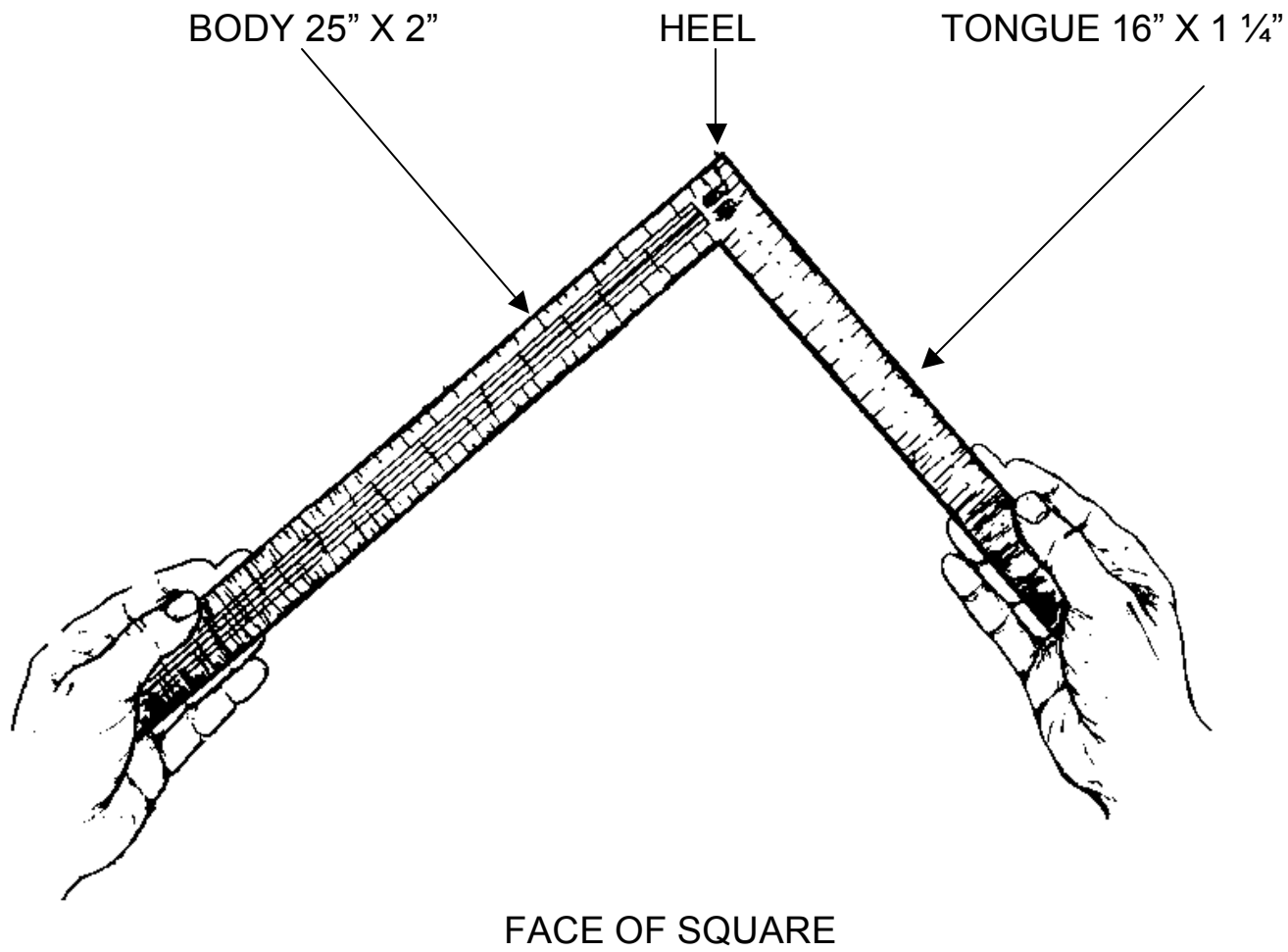
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## PARTS OF A ROOF



130P-21

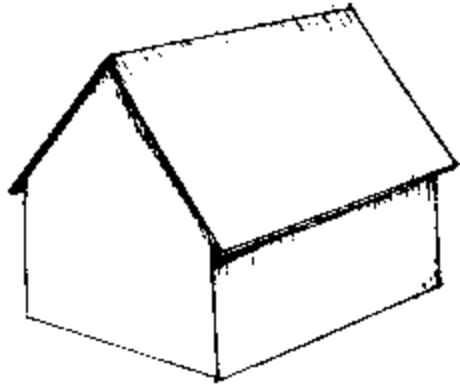
## PARTS OF A FRAMING SQUARE



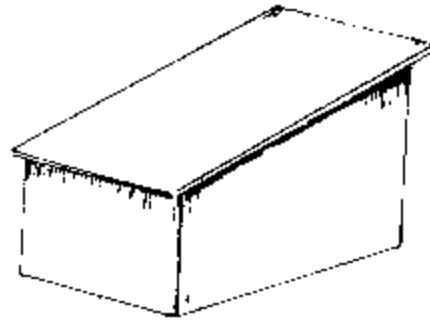
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## TYPES OF ROOFS

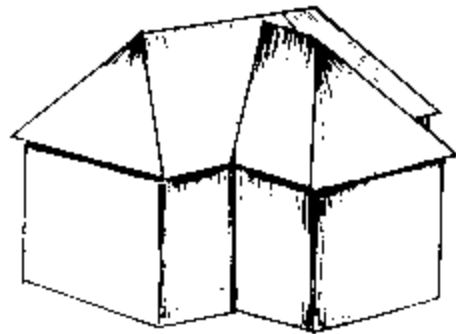
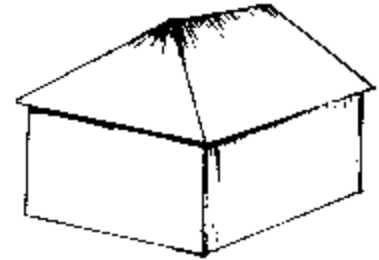
GABLE



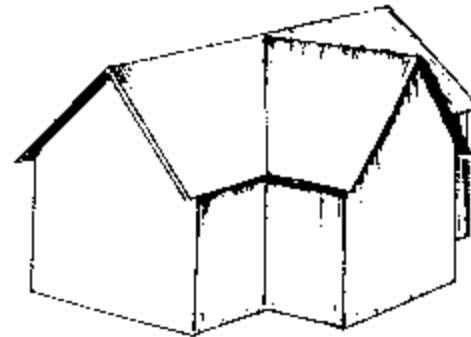
LEAN-TO



HIP

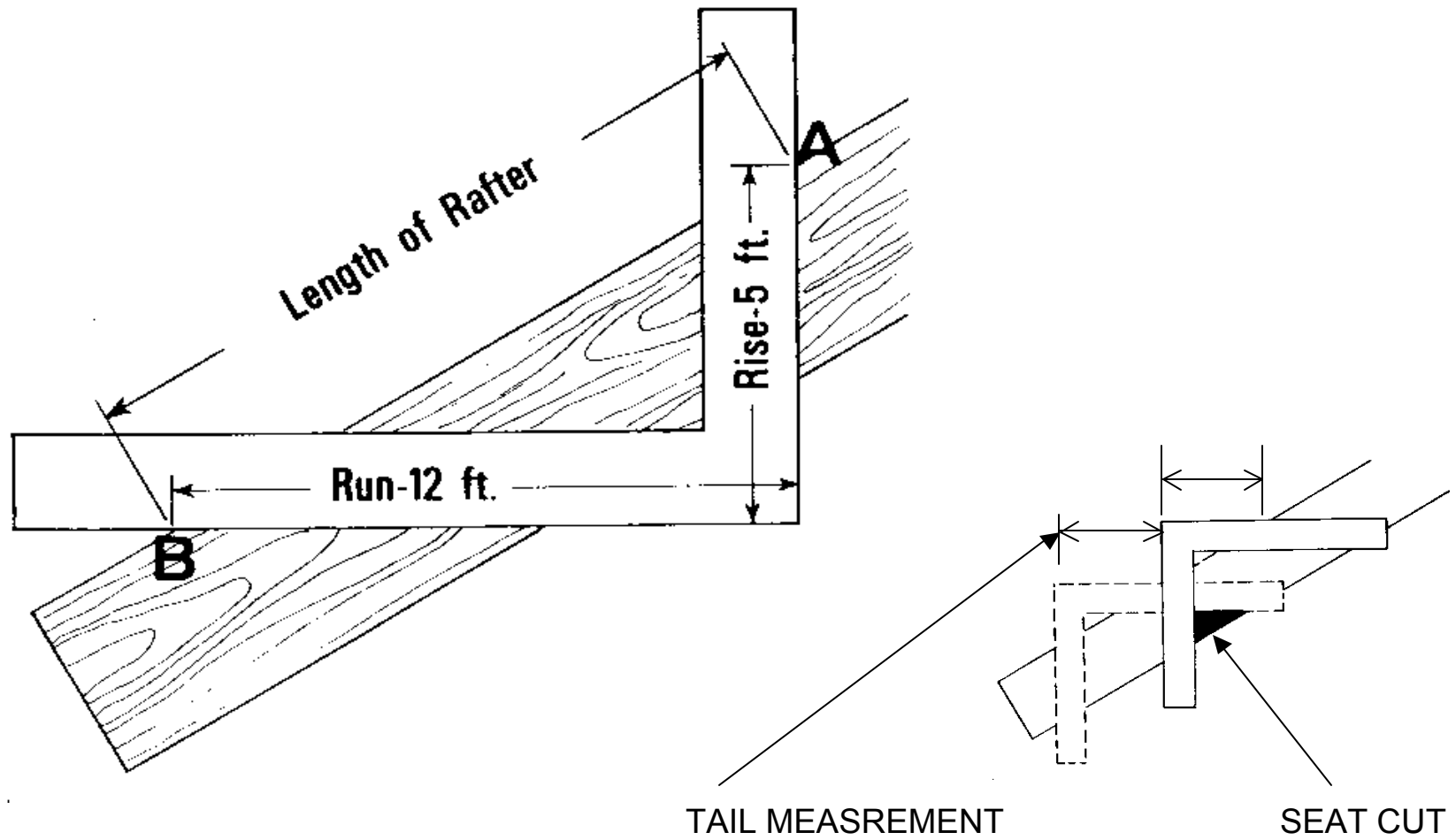


HIP AND VALLEY



GABLE AND VALLEY

## MARKING AND CUTTING A RAFTER



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## FRAMING SQUARE TABLES

RAFTER TABLE

BRACE TABLE

